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AUTHOR McAuliffe, Elizabeth A.; Trueblood, Cecil R.
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ABSTRACT

Mathematics anxiety and its relationship to other constructs was studied in 138 preservice elementary and special education teachers. The students, primarily women, were enrolled in a variety of professional courses and field experiences. Five instruments were administered, their factor structures were determined, and intercorrelations among the factors of the tests were examined: Mathematics Anxiety Rating Scale (MARS), State Trait Anxiety Inventory (STAI), Suydam-Trueblood Attitude Toward Mathematics Scale (MAS), Askov-Trueblood Attitude Toward Reading Scale (RAS), and Test Anxiety Inventory (TAI). In addition, the relationship of the MARS to the other tests and to other student variables was investigated: age, grade point average, teaching preference, and number of high school and college mathematics courses. Principal components analysis was used to determine the factor structure of the tests. After weighting and additional refactoring were performed, the results indicated the following factors: (1) for the MARS--evaluation, performance, and quantification; (2) STAI--state anxiety and trait anxiety; (3) MAS--feelings toward mathematics in general, mathematics performance, and mathematics class; (4) RAS--feelings toward reading in general and in the classroom; and (5) TAI--emotionality and worry. MARS scores correlated significantly and positively with STAI, MAS, and TAI total scores. (Factor loadings and specific items are included). A reference list is appended. (GDC)

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FACTOR ANALYSIS: A TOOL FOR STUDYING MATHEMATICS ANXIETY

Elizabeth A. McAuliffe, RSM

Salve Regina - The Newport College, Newport, Rhode Island

Cecil R. Trueblood

The Pennsylvania State University

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FACTOR ANALYSIS: A TOOL FOR STUDYING MATHEMATICS ANXIETY

INTRODUCTION

That mathematics anxiety has become an issue with which to contend is hardly disputable. Even a cursory glance at the research literature in the area reveals an overwhelming concern by educators to make sense out of a rather ambiguous arena (Fennema & Sherman, 1978; Fennema & Carpenter, 1981; Tobias, 1978, 1980; Richardson & Suinn, 1972). The construct entitled "mathematics anxiety" seems to have its roots in the larger psychological construct "anxiety." A review of the related psychological literature (Spielberger, 1966, 1975; Sarason, 1957) gives evidence that anxiety is a vague, elusive term. Rollo May (1980) points out that there are several orientations in the literature about general anxiety: philosophical, biological, psychological, and cultural. For the purposes of this study, consideration was given to Spielberger's psychological conception of trait anxiety and state anxiety. Phillips, Martin, and Meyer (1972) operationalize this conception suggesting that anxiety is a response to stressors in the environment. Anxiety is thus defined both as an external way of responding and as an underlying internal base from which to operate. Trait anxiety refers to that internal disposition with which a person approaches life situations in general. State anxiety is less

enduring and more external. It focuses on a particular event in time (i.e., math class).

An appreciation of the elusive nature of general anxiety helps one to recognize the difficulty in establishing and validating the construct "mathematics anxiety." In the research literature, mathematics anxiety is viewed as a particular "fear of" or phobia for" mathematics. It is believed this fear inhibits the person involved from succeeding in situations, informal and/or formal, in which recourse to elements of mathematics is necessary.

This study was concerned with the debilitating aspect of anxiety. More precisely it was concerned with preservice elementary teachers' mathematics anxiety and its relationship to other constructs. The preservice elementary teachers in this study were predominately women. It is the belief of this investigator and of others (Byrd, 1982; Resnick, Viehe, & Segal, 1982) that knowledge of the specific makeup of the construct mathematics anxiety is prerequisite to providing the necessary interventions to quell the debilitating anxiety considered in this particular study. Other studies (Betz, 1978; Byrd, 1982; Llabre & Suarez, 1984) have focused on total score correlations in an attempt to gain knowledge of the construct mathematics anxiety. In addition to considering total score correlations, this study focuses on intercorrelations of factors of the instruments used. Thus, this study had three goals. The first of

these goals was to identify the factor structure of the Mathematics Anxiety Rating Scale (MARS), State-Trait Anxiety Inventory (STAI), Suydam-Trueblood Attitude Toward Mathematics Scale (MAS), Askov-Trueblood Attitude Toward Reading Scale (RAS), and Test Anxiety Inventory (TAI). The second goal was to determine to what extent the MARS was related to the STAI, MAS, RAS, TAI, and selected organic variables (age, grade point average (GPA), teaching preference, number of high school mathematics courses, and number of college mathematics courses). Thirdly, this study examined the intercorrelations among the factors of the MARS, STAI, MAS, RAS, TAI, and the selected organic variables. This paper focuses primarily on the third of these three goals.

INSTRUMENTATION

Mathematics Anxiety Rating Scale

The Mathematics Anxiety Rating Scale is a 98-item scale containing brief descriptions of behavioral situations. The authors indicate that it "was constructed to provide a measure of anxiety associated with the single area of the manipulation of numbers and the use of mathematical concepts" (Richardson & Suinn, 1972, p.551).

Richardson and Suinn (1972) report a reliability coefficient for the MARS of .85 and an internal consistency reliability

coefficient, coefficient alpha, of .97. The alpha coefficient in this study was .98.

State-Trait Anxiety Inventory (STAI)

This paper-and-pencil inventory consists of two independent forms. The S-Anxiety scale measures the anxiety of an individual at a particular moment in time. The T-Anxiety scale measures the anxiety proneness of an individual. There are 20 statements in each scale to which the student must respond on a four-point scale ranging from feeling anxious "not at all" to "very much so."

Spielberger (1970) reports a 20-day test/retest reliability of r = .76 for the T-Anxiety scale. The reliability was calculated for female undergraduate students. A reliability of r = .27 was calculated for the S-Anxiety scale. Since the S-Anxiety scale measures a transient, momentary condition of anxiety, this is not considered an unusually low correlation coefficient.

Suydam-Trueblood Attitude Toward Mathematics Scale (MAS)

The Suydam-Trueblood Attitude Toward Mathematics scale is a Likert-type scale which consists of 13 positively worded and 13 negatively worded statements. The scale has been administered to several thousand students with a reliability (KR-20) of .96 (Fennell & Trueblood, 1977). This present study reports an alpha coefficient of .97.

Test Anxiety Inventory (TAI)

This 20-item inventory was developed by Spielberger (1980). It focuses on feelings and reactions an individual experiences while taking tests. Like the STAI, responses are given on a four-point scale. The alpha coefficient as reported by Spielberger (1980) for undergraduate college students is .94 for males and .95 for females. This present study reports an alpha coefficient of .96.

SAMPLE

The sample involved in this study was 138 preservice elementary and special education teachers most of whom were women. These students were enrolled in a variety of professional courses. Eighty-four (84) students were enrolled in a Professional Block of courses entitled Teaching Mathematics in the Elementary School, Teaching Reading in the Elementary School, and Field Experience in the Elementary School. The two 10-week methods courses, Mathematics and Reading, are designed to acquaint students with basic information related to the theory and practice of teaching mathematics and reading in the elementary school classroom. The five-week field experience which immediately follows the methods courses offers the students an opportunity to engage in actual teaching experience which incorporates the university classroom experience of the previous 10 weeks.

Twenty-three (23) students were enrolled in a mathematics education course (CI 408) which focuses on methods to be used in the special education classroom. Another 31 students were enrolled in an elementary social studies methods course. In general, all students were juniors and seniors who have had from one (1) to six (6) high school mathematics courses with 43.5% of the students having taken between four (4) and six (6) high school mathematics courses including trigonometry.

Of the 138 students, 79.7% have taken between one (1) and three (3) college mathematics courses without calculus. The remaining 20.3% have had three or more courses including calculus.

METHODOLOGY

This study was designed to test and to describe the association among preservice elementary teachers' scores on the MARS, STAI, MAS, RAS, TAI, their age, GPA, teaching preference, number of high school mathematics courses, and number of college mathematics courses and to test related hypotheses. This particular sample is significant if mathematics anxiety is seen as a unique construct, since it is the preservice elementary teacher who eventually will be instructing others in the area of mathematics. Initially, biographical data were gathered for each student. To provide a more precise description of the associations between the MARS, STAI, MAS, RAS, TAI, and the organic variables, a principal components analysis was used to

determine the factor structure of the MARS, STAI, MAS, RAS, and TAI.

Both total scores and factor scores were used in the measurement of the relationships among the scores on the instruments and the organic variables. To maximize internal consistency, factor scales were formed by initially performing separate factor analyses on the subset of items with heaviest loadings on each of the factors of each of the instruments and secondly determining weights for the items comprising each scale using factor coefficients derived from the sub-analysis (Armor, 1974). This procedure was followed in order to ascertain more clearly what mathematics anxiety is and what it is not. The SCORE program (SAS, 1982) was used to arrive at factor scores for each of the subjects in this study for each of the instruments. These factor scores were then correlated using the Pearson Product-Moment Correlation computer program.

Total score correlations were determined using subjects' raw scores and applying the Pearson Product-Moment Correlation to the data.

RESULTS

Table 1 shows that after refactoring, the factor structure for the MARS, STAI, MAS, and TAI was as follows:

MARS: Three factors: Evaluation, Performance, Quantification

Table 1. Listing of Factors Associated with the MARS, STAI, MAS, RAS, and TAI with Total Variance Accounted for and Variance Accounted for by Each Factor Before and After Refactoring

Instrument	Factors	Accounted for Variance Before (After) Refactoring	Total Variance Before (After)
MARS	1. Evaluation	23.86 (25.88)	
	2. Performance	12.29 (10.79)	
	3. Quantification	9.59 (9.01)	
			45.74 (45.68)
STAI	1. State Anxiety	9.39 (9.32)	
	2. Trait Anxiety	8.25 (8.11)	
			17.64 (17.43)
MAS	1. General Feelings Toward Mathematics	8.23 (13.17)	
	2. Feelings Toward Mathematics Performance	5.14 (9.15)	
	3. Feelings Toward Mathematics Class	4.07 (4.48)	
			17.44 (26.80)

Table 1 (continued)

Instrument	Factors	Accounted for Variance Before (After) Refactoring	Total Variance Before (After)
RAS	1. Feelings Toward Reading in General	6.82 (6.62)	
	2. Feelings Toward Reading in Classroom Situations	6.32 (6.47)	
			13.14 (13.09)
TAI	1. Emotionality	7.79 (9.77)	
	2. Worry	7.79 (9.77)	
			15.58 (19.54)

STAI:	Two factors:	State Anxiety, Trait Anxiety
MAS:	Three factors:	General Feelings Towards Mathematics, Feelings Towards Mathematics Performance, Feelings Toward Mathematics Class
TAI:	Two factors:	Emotionality, Worry

Table 2 shows that MARS total scores correlated significantly and positively with total scores of the STAI (.49), MAS (.71), and TAI (.43).

In addition, Table 2 shows the correlations of weighted factors of the MARS with weighted factor scores of the STAI, MAS, and TAI. The first of the three MARS factors, Evaluation correlated positively and significantly with both factors of the STAI, State Anxiety (.43), Trait Anxiety (.42); with the three factors of the MAS General Feelings Toward Mathematics (.76), Feelings Toward Mathematics Performance (.79), Feelings Towards Mathematics Class (.70); and with both factors of the TAI, Emotionality (.42), Worry (.37). The Evaluation factor explains 25.88 percent of the variance after this factor was refactored for a one-factor solution. Prior to the refactoring process, the Evaluation factor accounted for 23.86 percent of the variance.

Table 2. CORRELATIONS OF TOTAL SCORES AND WEIGHTED FACTOR SCORES OF MARS WITH WEIGHTED FACTOR SCORES OF STAI, MAS, AND TAI, (N=138)

	MAS				STAI			TAI		
	FACTOR 1 GENERAL	FACTOR 2 PERFORMANCE	FACTOR 3 CLASS	TOTAL SCORE	FACTOR 1 STATE	FACTOR 2 TRAIT	TOTAL SCORE	FACTOR 1 EMOTIONALITY	FACTOR 2 WORRY	TOTAL SCORE
MARS-TOTAL SCORE	-	-	-	.71***	-	-	.36****	-	-	.29***
MARS-FACTOR 1 EVALUATION	.76****	.79****	.70****	-	.43****	.42****	-	.42****	.37****	-
MARS-FACTOR 2 PERFORMANCE	.57****	.57****	.55****	-	.40****	.41****	-	.35****	.28***	-
MARS-FACTOR 3 QUANTIFICATION	.39****	.42****	.40****	-	.32****	.44****	-	.31***	.29***	-

* Significant at $\leq$ .05 (r=.16)

*** Significant at $\leq$ .001

**** Significant at $\leq$ .0001

MARS - Mathematics Anxiety Rating Scale
MAS - Mathematics Attitude Scale
STAI - State-Trait Anxiety Inventory
TAI - Test Anxiety Inventory

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The items in this factor reflect a concern about test taking, problem solving, course-related elements (i.e., textbooks, instructor, signing up for a course, etc.), and a subtle external concern with another's perception (beside the teacher's) of one's work. The elements suggest a concern with evaluation from a variety of perspectives.

The second factor of the MARS, Performance, accounts for 10.79 percent of the variance after refactoring. Items in this factor focus on the actual "doing" of mathematics both in the traditional school setting and in a social setting. The Performance factor correlates positively and significantly with both factors of the STAI, State Anxiety (.40), Trait Anxiety (.41); with the three factors of the MAS, General Feelings Toward Mathematics (.57), Feelings Toward Mathematics Performance (.57), Feelings Toward Mathematics Class(.55); and both factors of the TAI, Emotionality (.42), Worry (.47).

The third factor of the MARS, Quantification, accounts for 9.01 percent of the variance, after having been refactored for a one-factor solution. Items in this grouping concern quantitative elements such as historical dates, number of college credits, budgets, and tallies. The Quantification factor correlates positively and significantly with both factors of the STAI, State Anxiety (.32), Trait Anxiety (.44); with the three factors of the MAS, General Feelings Toward Mathematics (.39), Feelings Toward Mathematics Performance (.42), Feelings Toward Mathematics Class (.40); and with both factors of the TAI, Emotionality (.31) Worry (.29).

Discussion

Viewing only total score correlations, as is popular (Llabre and Suarez, 1984; Brush, 1978), limits the understanding of mathematics anxiety and its relationship to other constructs. The strong relationship of each of the factors of the MARS to each of the factors of the MAS would suggest that the constructs "mathematics anxiety" and "mathematics attitude" are similar in nature. Both constructs focus on a person's feelings towards mathematics. The difference in the way each construct is measured appears to be a factor of the item structure of each instrument. Table 3 shows that items in the MAS reflect a concern with a variety of feelings toward mathematics, i.e. irritability, anger, enjoyment, challenge, like, dislike, fear, while Table 4 shows that items in the MARS focus on situational aspects in which a person experiences fear or lack of fear related to mathematics. These experiences can be active or passive. Active situations involve a person actually doing something related to mathematics i.e. determining the amount of change that should be received, being asked to perform some operation on a set of numbers; walking to mathematics class; signing up for a mathematics course, etc. Passive situations involve a person watching or listening to another person i.e. watching someone work with a slide rule; listening to another student explain a mathematics formula; watching someone work with a calculator.

Similarly, this study supports the findings of other studies

Table 3. Selected Items from Each of the MAS Factors with both Refactored and Original Factor Loadings Listed in Order of Decreasing Factor Loadings

Factor 1	General Feelings Toward Mathematics		
Loadings		Item	
Refactored	Original	Number	Statement
.874	.71	16	I feel good toward mathematics
.871	.58	10	When I hear the word mathematics, I have a feeling of dislike
.81	.57	1	Mathematics often makes me feel irritable and angry
.81	.63	13	I like anything with numbers in it
.76	.44	6	Mathematics is a stimulating and interesting subject
Factor 2	**Feelings Toward Mathematics Performance**		
.88	.60	15	I usually feel calm when doing mathematics problems
.82	.42	8	I feel sure of myself when doing mathematics
.81	.42	3	I think my mind works well when doing mathematics problems

Table 3 (continued)

Loadings		Item	Statement
Refactored	Original	Number	
.80	.44	2	I usually feel happy when doing mathematics problems
.69	.49	21	I would rather do anything else than do mathematics
Factor 3	Feelings Toward Mathematics Class		
.88	.56	12	Mathematics is fun
.76	.64	26	Time drags in a mathematics lesson
.71	.59	18	I think about mathematics problems outside of class and like to work them out
.65	.81	25	Mathematics class stimulates me to look for ways of applying mathematics to solving practical problems

Table 4. Selected Items from Each of the MARS Factors with both Refactored and Original Factor Loadings Listed in Order of Decreasing Factor Loadings

Factor 1	Evaluation		
Loadings		Item	
Refactored	Original	Number	Statement
.87	.80	53	Taking an examination (quiz) in a math course
.82	.77	86	Open a math or stat book and seeing a page full of problems
.81	.76	71	Picking up the math text book to begin working on a homework assignment
.81	.80	26	Signing up for a math course
.76	.69	28	Walking into a math class
.64	.56	25	Watching a teacher work an algebraic equation on the blackboard
.50	.40	92	Seeing a computer printout
Factor 2	Performance		
.75	.60	66	Working on an abstract mathematical problem, such as: "If x = outstanding bills, and y = total income, calculate how much you have left for recreation expenditures."

Table 4 (continued)

Loadings		Item	
Refactored	Original	Number	Statement
.74	.55	46	Reading and interpreting graphs or charts
.71	.45	12	Being treasurer for a club
.68	.57	29	Having to compute the miles/gallon on your car
.63	.52	6	Calculating a simple percentage e.g., the sales tax on a purchase
Factor 3	Quantification		
.83	.63	87	Being responsible for collecting dues for an organization and keeping track of the amount
.72	.65	90	Figuring out your monthly budget
.68	.49	32	Working on an income tax form
.64	.40	97	Tallying up the results of a survey or poll
.58	.58	63	Juggling class times around at registration to determine the best schedule

(Betz, 1978; Hendel, 1980; Llabre & Suarez, 1984) which state that mathematics anxiety is significantly related to both state and trait anxiety. Table 2 shows that each of the factors of the MARS was positively and significantly correlated with state anxiety. It should be noted further that each of the factors of the MARS is also positively and significantly correlated with trait anxiety, the second factor of the STAI. Further study of Table 2 shows that each of the factors of the MARS is significantly related to both factors of the TAI (worry & emotionality). Thus, it would appear that Morris, Kellaway, & Smith (1978) are accurate in their assumption "that the MARS is a situation-specific trait anxiety measure, indicating proneness to experience state anxiety in evaluative situations involving mathematics" (p. 593).

The fact that the MAS and STAI are positively and significantly related, though not to the same degree, may be accounted for by the fact that the preservice elementary teachers involved in this study were at the beginning of a mathematics methods course and were experiencing anxiety at the thought of pursuing this mathematics course.

Other studies (Myers, 1983; Fernsler, 1983; Gonzales, 1983) indicate that attitudes towards mathematics can be manipulated and hence improved through instruction. If Reyes (1980) is correct in saying that mathematics anxiety is simply an expression of an attitude toward mathematics then there is good

reason to believe that mathematics anxiety can also be manipulated.

The results of the present study emphasize that mathematics anxiety, mathematics attitude, general anxiety and test anxiety are interrelated. This fact ought to influence future research related to intervention strategies intended to decrease mathematics anxiety. While it appears intuitively obvious that greater knowledge of mathematics through additional coursework will decrease a person's mathematics anxiety, it is not always acted upon. Women in particular are often discouraged from pursuing higher level mathematics courses. While this phenomenon seems to be decreasing as we approach the 1990s, more needs to be done. It remains to be seen if recent changes in curriculum policies which require more mathematics of all students will prove successful in the diminishment of mathematics anxiety.

A consideration of the factor structure of the MARS suggests further that, for this sample, evaluation plays a significant role in the consideration of mathematics anxiety. This factor not only encompasses traditional test taking activities but also activities in which a person is faced with external perceptions of his/her work. The strong relationship of the Evaluation factor to General Feelings Toward Mathematics, Feelings Toward Mathematics Performance, and Feelings Toward Mathematics Class would suggest that serious consideration ought to be given to the influence of evaluation on mathematics. This is ultimately the

work of mathematics educators. Questions ought to be raised regarding the methods used to determine the goals of mathematics evaluation. Is the type of evaluation presently being used by mathematics educators contributing to the mathematics anxiety of mathematics students? While definitive answers to this question are beyond the scope of this paper, future studies should focus attention on the impact of evaluation on mathematics anxiety. The curriculum implications of the findings presented in this paper have been discussed in another place (McAuliffe & Trueblood, 1986).

The relationship of each of the three factors of the MARS to the Emotionality factor of the TAI ranges from .42 (Evaluation) to .31 (Quantification) and for the Worry factor of the TAI from .37 (Evaluation) to .29 (Quantification). The moderate range of these correlations suggests that at least a portion of the anxiety experienced by the students involved in this study was related to their anxiety about being in a situation which was personally threatening (Emotionality) and/or a situation which could result in failure (Worry). At least part of the evaluation anxiety felt by students in this study was due to the actual testing situation.

Unlike the Evaluation factor, the performance factor and the quantification factor appear to be more focused in their content (Table 4) focusing on the "doing" of mathematics. The relationship of the Performance factor of the MARS to the Worry factor of the TAI (.47) implies a concern about failing in the actual performance of mathematics activities.

Clearly, more work needs to be done which focuses on the individual factors of the MARS as they relate to other measures, namely math attitude measures and measures of test anxiety. The value of the present study is in its attempt to isolate the various components of mathematics anxiety, as determined by the MARS, through the use of a factor analytic process which assures greater internal consistency. Once isolated these factors can then be correlated with factors from other instruments similarly obtained. Consideration of the factor structure of the MARS reveals that Evaluation remains the overpowering construct influencing mathematics anxiety. Other studies need to be designed which will (1) refine the instruments used to measure mathematics anxiety and (2) identify the amount of unique variance due to mathematics anxiety, state-trait anxiety, and test anxiety.

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